Incheon Bridge Elastomeric Bearings & Pot Bearings

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Abstract: Incheon Bridge which is the greatest bridge project in Korea has been applied by 1,092 numbers bridge bearing in accordance with AASHTO LRFD. Two types of bridge bearing, pot bearing and elastomeric bearing, have been installed in elevated viaducts, cable stayed bridge and other bridges like connection bridges and over pass bridges. Pot bearings and elastomeric bearings are commonly used in the bridges worldwide sine early 1950's and these bearings are recognized as one of the best solution for load carrying capacity and movement/rotation function for whole life of such a grand bridge and for easy maintenances under the service.

1. Introduction

1.1 Major function of bearings

Bridge bearings accommodate

- Vertical load such as live load and dead load.
- Horizontal load such as wind load and earthquake
- Rotation due to superstructure deformation and traffic load
- Movement due to temperature variation and creep/shrinkage during construction
- Uplift forces due to torsion and earthquake

Elastomeric Bearings are deformed to accommodate the aforementioned loads and It's typical shapes are shown as below.

Steel-reinforced elastomeric bearings, used for the highest loads, as shown in Figure 1.1. Steel plates are bonded with rubber, either natural or polychloroprene, in alternating layers to form a sandwich.

The finished product contains rubber cover on the top and bottom and around the edges, creating a sealed system in which the plates are protected against corrosion.

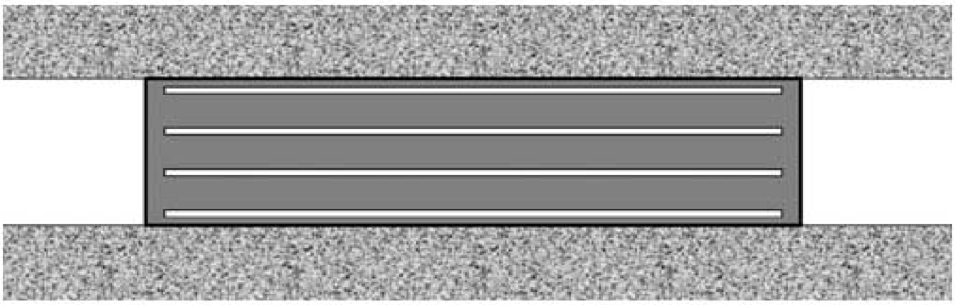


Figure 1.1. Cross-section of a steel-reinforced elastomeric bridge bearing.

The simplest concept for accommodating expansion or contraction of the girders is to do so through the elastomeric shear deformations of a plain rubber block. As the bridge expands, the block changes shape from a rectangle to a parallelogram as shown in Figure1.2

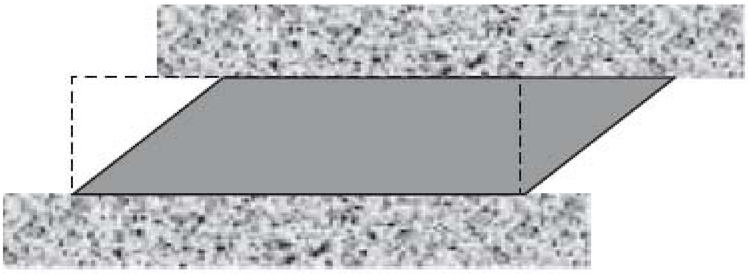
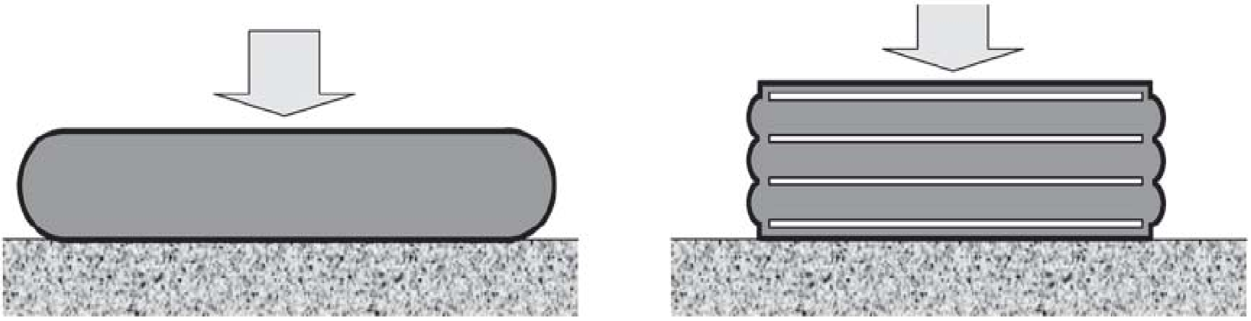


Figure 1.2. Elastomeric plain pad shearing to accommodate girder expansion.

A plain elastomeric pad responds to vertical load by ex-panding laterally and slipping against the supporting surface as shown in Figure 1.3a. The rubber in laminated pad is largely prevented from such expansion by its bond to the steel plates, and the layers only form small bulges, as shown in Figure 1.3b



(a) (b)

Figure 1.3. Bulges without (a) and with (b) steel plates.

Pot bearings are belonging to the mechanical bearings as shown below.

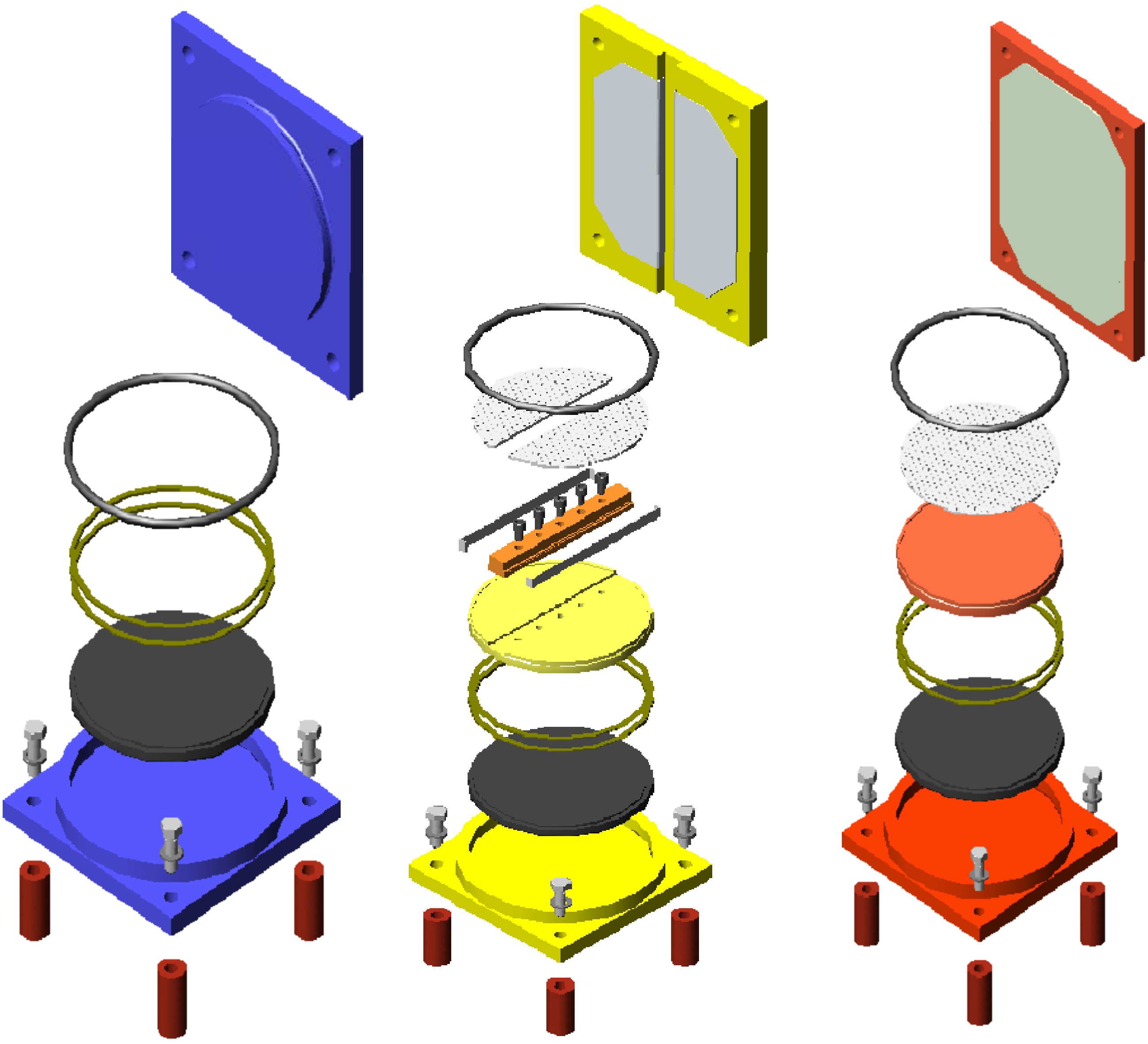


Figure 4. Type of Pot bearing

1.2 Design specifications (AASHTO LRFD)

The AASHTO LRFD Design specifications, 4th Edition, Section 14 pertains to bridge joints and bearings and contains two design methods for elastomeric bridge bearings: Method A and Method B. Method A is very simple and has tighter limits on stresses, while Method B requires a more detailed design but allows for greater loads. It is also associated with more stringent testing procedures.

1.2.1 Method A

Method A specifies that shear modulus of the elastomer should be between 0.080 ksi and 0.250 ksi, and nominal hardness should be between 50 and 70 on the Shore A scale, and all other physical properties

should conform to ASTM D 4014. The service level axial stress is limited by

$\delta_a \leq 1.0GS$ and $\delta_a \leq 1.0$ksi

δ_a= the average axial stress

G = the shear modulus of the elastomer.

The shear deflection is governed by

$$\Delta_s \leq \frac{h_{rt}}{2}$$

h_{rt} is the total thickness of elastomer. To ensure that lift-off is prevented, the rotation and axial stress must satisfy

$$\sigma_a \geq 0.5GS\left(\frac{L}{h_{ri}}\right)^2 \frac{\theta_x}{n}$$

θ_x= the rotation applied to the bearing about the x-axis

hri = the thickness of one rubber layer

n = number of internal rubber layers

Lastly, the length and width of bearing must each be greater than three times the total thickness to prevent instability.

1.2.2 Method B

Method B specifies that shear modulus of the elastomer should be between 0.0080ksi and 0.175ksi, and nominal hardness should be between 50 and 60 on the Shore A scale. All other physical properties should conform to ASTM D 4014. For bearings subject to shear deformations, total axial stress is governed by

$\delta_a \leq 1.66GS$ and $\delta_a \leq 1.66$ksi

The live load stress also is required to be less than 0.66GS. Total load stress limits are increased to 2.0GS and 1.75ksi if shear displacement is prevented. The limit for shear displacement, Δ_s, is identical to that in Method A.

Combinations of axial load and rotation are governed by the need to prevent lift-off and to avoid excessive shear strain on the compressive side of the bearing.

The governing equation for prevention of lift-off is

$$\sigma_a \geq 1.0GS\left(\frac{L}{h_{ri}}\right)^2 \frac{\theta_x}{n}$$

Preventing excessive shear strain on the compressive side

$$\sigma_a \leq 1.875GS\left[1 - 0.2\left(\frac{L}{h_{ri}}\right)^2 \frac{\theta_x}{n}\right]$$

These two equations bound the axial stress. Any stress rotation pair lying between them will neither lift off nor cause excessive compression.

2. Manufacturing Process

2.1 Elastomeric bearings

1. PAD Seat Cutting

2. Shot blasting

3. Apply the adhesives

4. Pre-lining

5. Preheating

6. Molding

7. Molding Complete

8. Shooting out

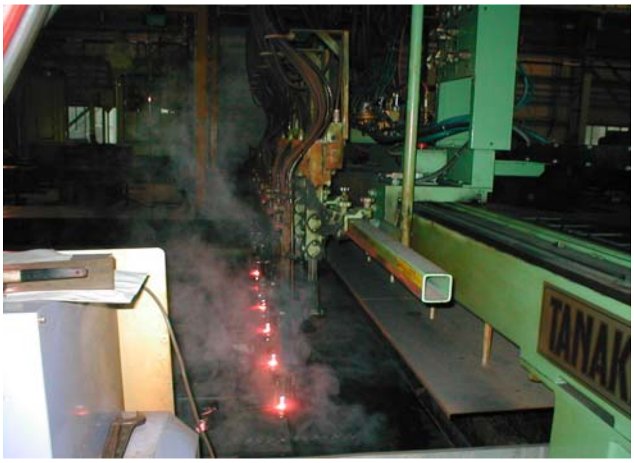
9. Finished product PAD(before machining)

10. Finished product PAD(after machining)

11. Testing

12. Delivery

2.2 Pot Bearings



1. Cutting

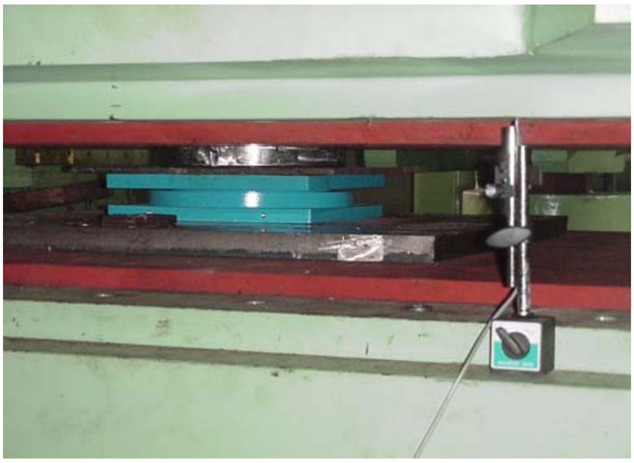

2. Machining


3. Machining(Base plate)


4. Machining(Top plate)


5. Painting


6. Assembly

	
7. Assembly(Top plate)	8. Assembly(piston)
	
9. Assembly(base plate)	10. Assembly(PTFE)
	
11. Assembly Complete	12. Testing

3. Testing

3.1 Performance test for elastomeric bearing

3.1.1 Short-term compression test

This test is according to the AASHTO LRFD 18.2.5.6

a) Test method

- A elastomeric bearing shall be setting the test instrument.
- The bearing shall be loaded in compression to150% of its rated service load
- Maintain the load about five minutes
- Remove the load
- The bearing shall be loaded in compression to150% of its rated service load again
- Maintain the load about five minutes

3.1.2 Long-term compression test

This test is according to the AASHTO LRFD 18.2.5.7

a) Test method

- A elastomeric bearing shall be setting the test instrument.
- The bearing shall be loaded in compression to150% of its rated service load
- Maintain the load about five minutes
- Remove the load
- The bearing shall be loaded in compression to150% of its rated service load again
- Maintain the load about 15hours

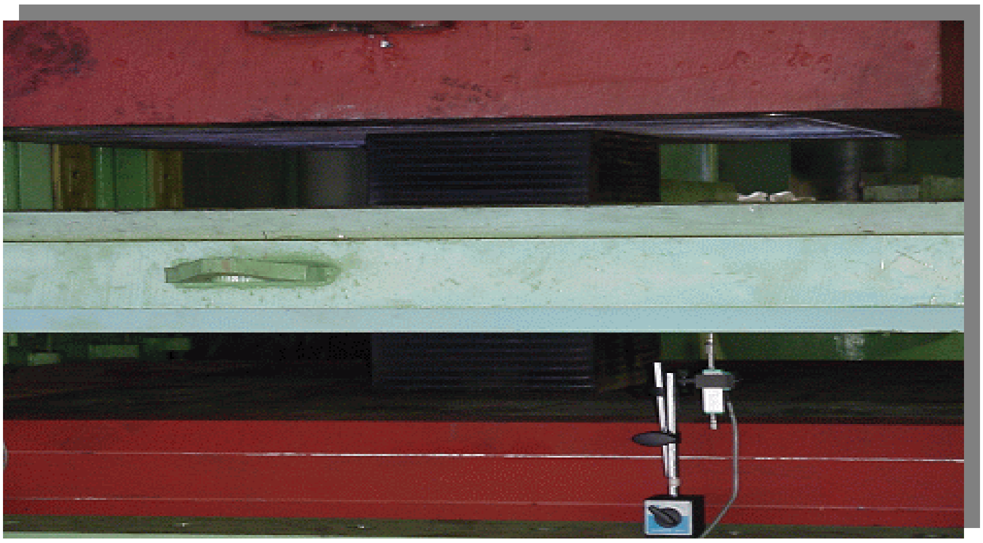


Figure 5. Shot term & Long term test

3.1.3 Shear modulus test

This test is according to the AASHTO LRFD 18.2.5.8

a) Test method

- Two elastomeric bearing shall be installed in test instrument.
- Apply the dead load.
- The bearings shall be taken the maximum load($0.7\times To^{*} \sim 0.9\times To^{*}$) and return the zero.
- Remove the compressive load and leave for 5 minutes.
- Record the horizontal deformation and strength
- Remove the compressive load and leave for 5 minutes.

b) Examination method

- Evaluation of each shear modulus

Figure 6. Shear modulus test

* To : Total thickness of elastomeric

3.2 Performance test for Pot bearing

3.2.1 Bearing friction test-sliding surfaces

This test is according to the AASHTO LRFD 18.1.5.2.6

a) Test method

- Two elastomerices shall be installed in test instrument.
- The bearing shall be loaded in compression with 100% of the full service dead load plus live load
- Horizontal load shall be maintained for one hour
- At least 12cycles of sliding, each consisting of the smaller of the design displacement and ± 25mm of movement, shall then be applied.
- The average sliding speed shall be 63mm per minute.

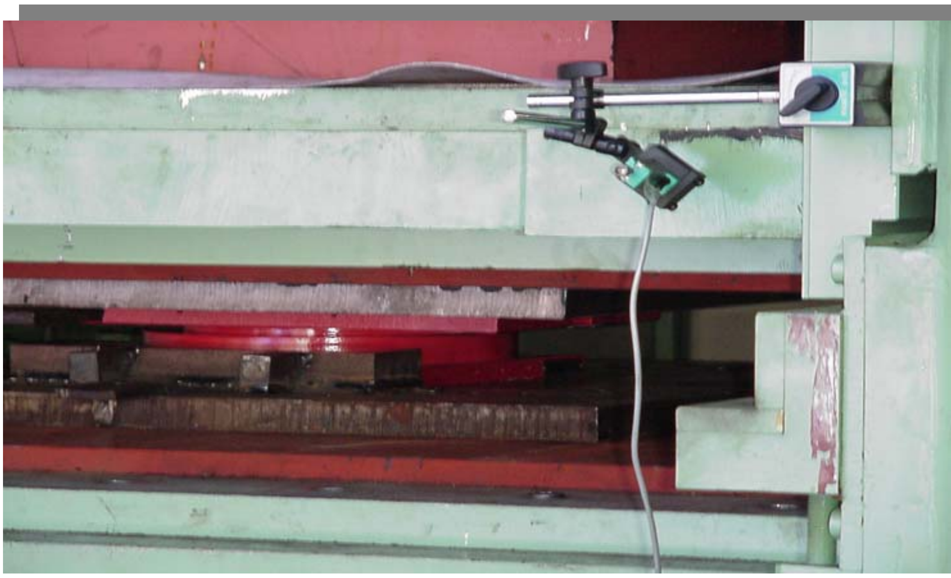


Figure 7. Vertical and Horizontal Load Test

3.2.2 Long-term deterioration test

This test is according to the AASHTO LRFD 18.1.5.2.7

a) Test method

- The test piece shall first be loaded in compression to stress corresponding to 100% of the maximum dad plus live service load.

3.2.3 Bearing horizontal force capacity

This test is according to the AASHTO LRFD 18.1.5.2.8

a) Test method

- One or more loading combinations, consisting of a horizontal and vertical service load which could exist simultaneously in the structure, shall be selected.
- The vertical load shall be applied first, at 1.0times its nominal value.
- The horizontal load shall be applied in slages, up to 1.5times its nominal value.

3.2.4 Clearance test

This test is according to the AASHTO LRFD 18.1.5.2.5

a) Test method

- The components of the bearing shall be moved through their design displacements or rotations to verify that the required clearances exist.

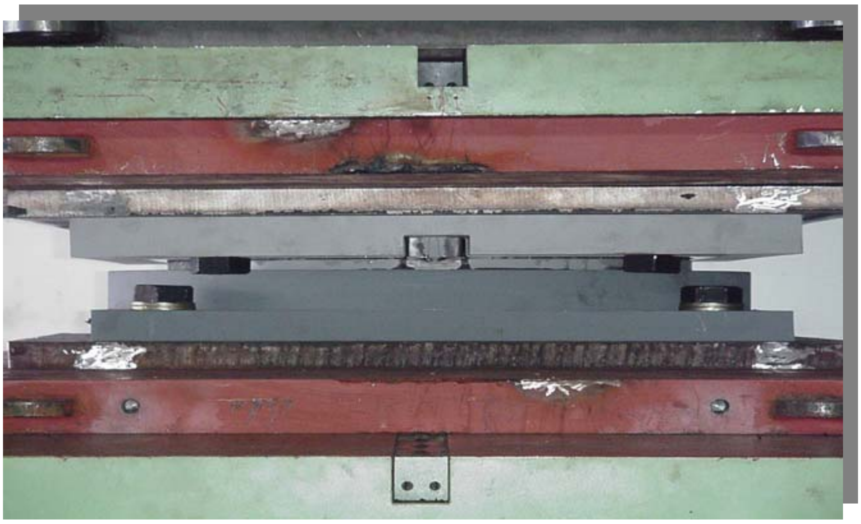


Figure 8. Rotation Test